Co-located in-situ and multi-frequency radar observations of ice clouds over the UK

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Parameterizing **I**ce **C**louds using **A**irborne ob**S**ervation**S** and triple-frequency d**O**ppler radar

Project Summary

- Coordinated triple frequency radar scans of large ice clouds
- Co-located airborne in-situ observations of microphysical properties
- Observations collected near the Chilbolton site in the UK
- Data collection: **January-February, and April 2018**

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Parameterizing **I**ce **C**louds using **A**irborne ob**S**ervation**S** and triple-frequency d**O**ppler radar

Objectives

- Obtain a dataset of ice cloud properties using co-located triple-frequency radar and in-situ airborne observations.
- Develop new multi-frequency radar retrievals of cloud properties, and evaluate existing dual and single frequency operational retrievals
- Investigate and parameterize cloud processes and properties, and compare observations with operational models to identify systematic biases
- Test microwave scattering models using triple wavelength radar analysis

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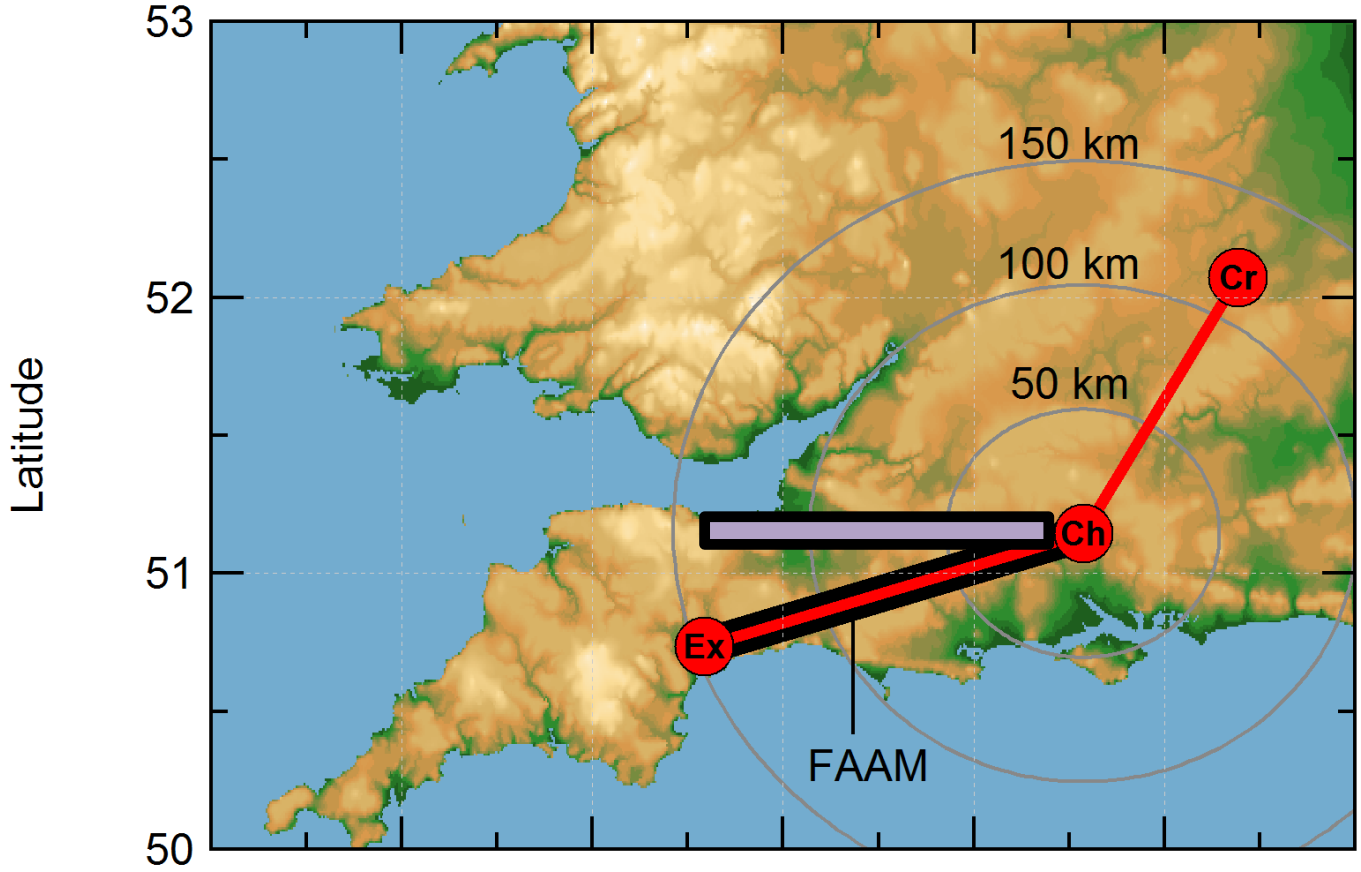

- **Two detachments to Cranfield during January-April 2018.**
- **Flight sorties along Chilbolton 255º/270˚ radial from CFARR.**
- **NERC funding for 60 flight hours + 30 from Met Office.**
- **Coordinated flights with GPM overpasses, where possible.**

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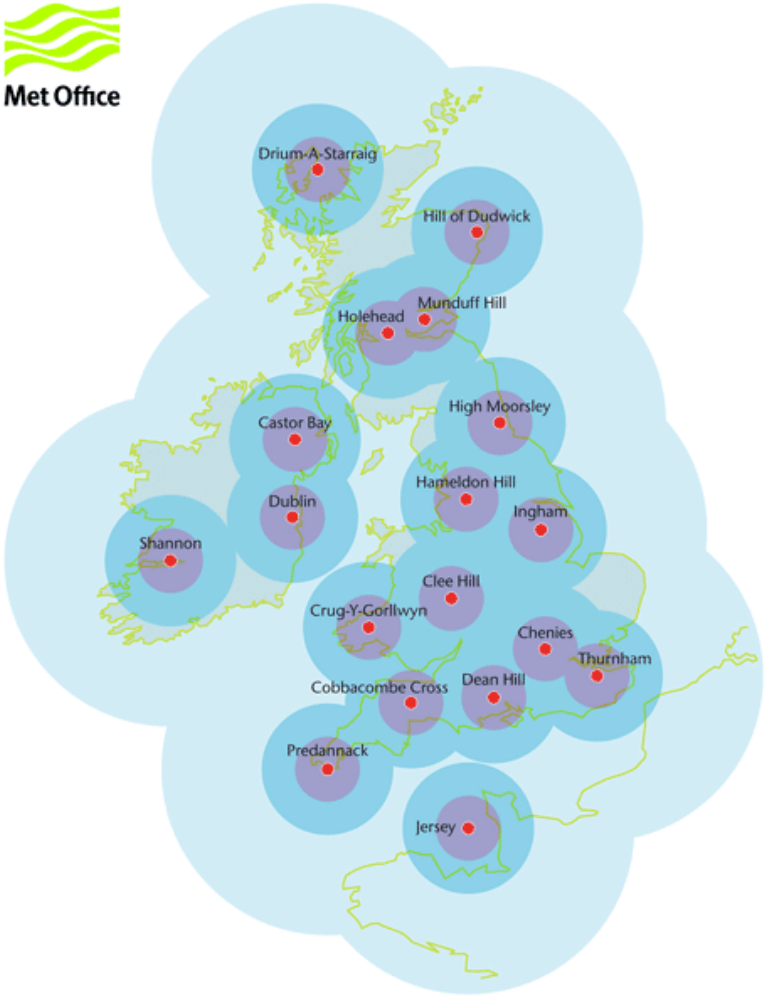
Other radars at Chilbolton

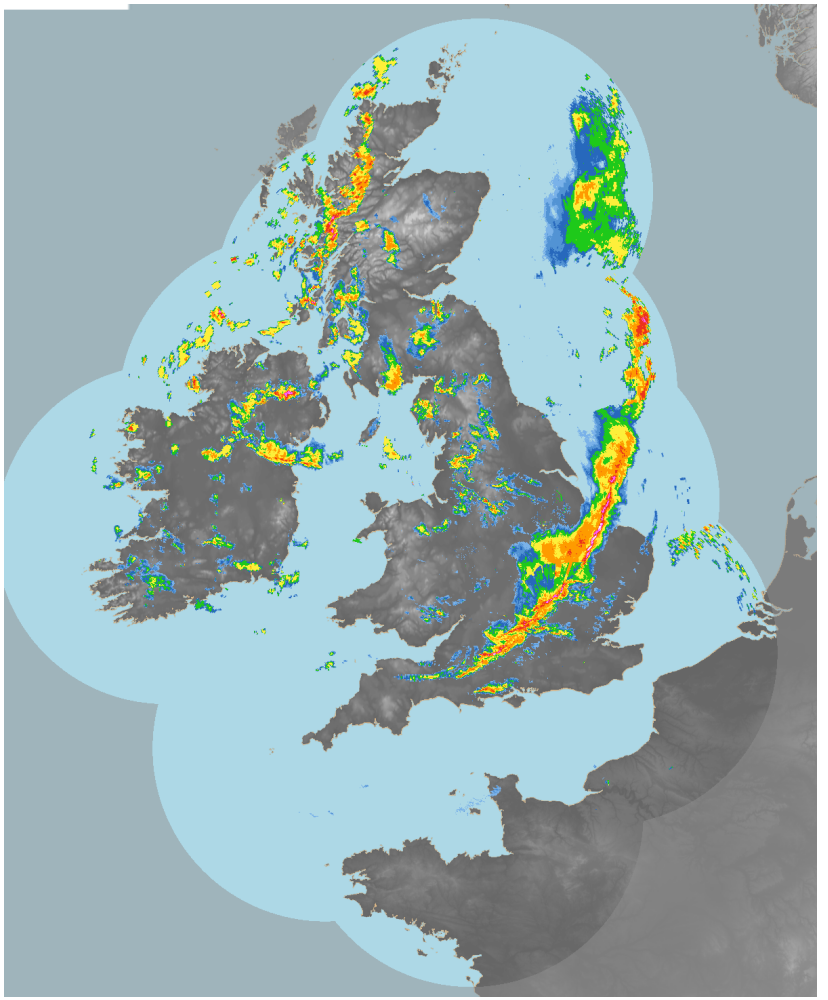
Mobile Ka Band

Mobile X-Band

UK Met Office Radar Network

- 18 operational C-band, Dual Pol, Doppler radars
- 1 additional “research” radar – 50km from Chilbolton





- S, Ka and W band synchronized RHI + PPI scans
- Additional Ka vertical pointing radar
- Additional X band doing weather surveillance and additional RHIs
- Full doppler spectra on all radars, dual pol on all except ?94? GHz.
- Typical beam width 0.25 deg, <100m range gates

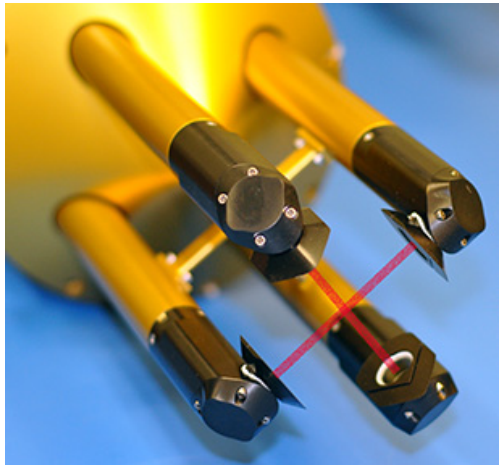
BAe146

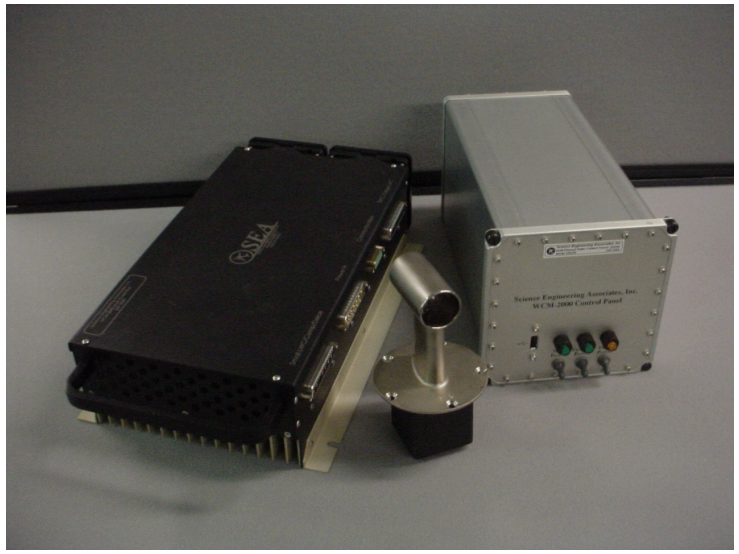
Typical endurance: 5 hours

Ceiling: 10-11km

Airspeed: 120 ms^{-1}

In-situ cloud probes

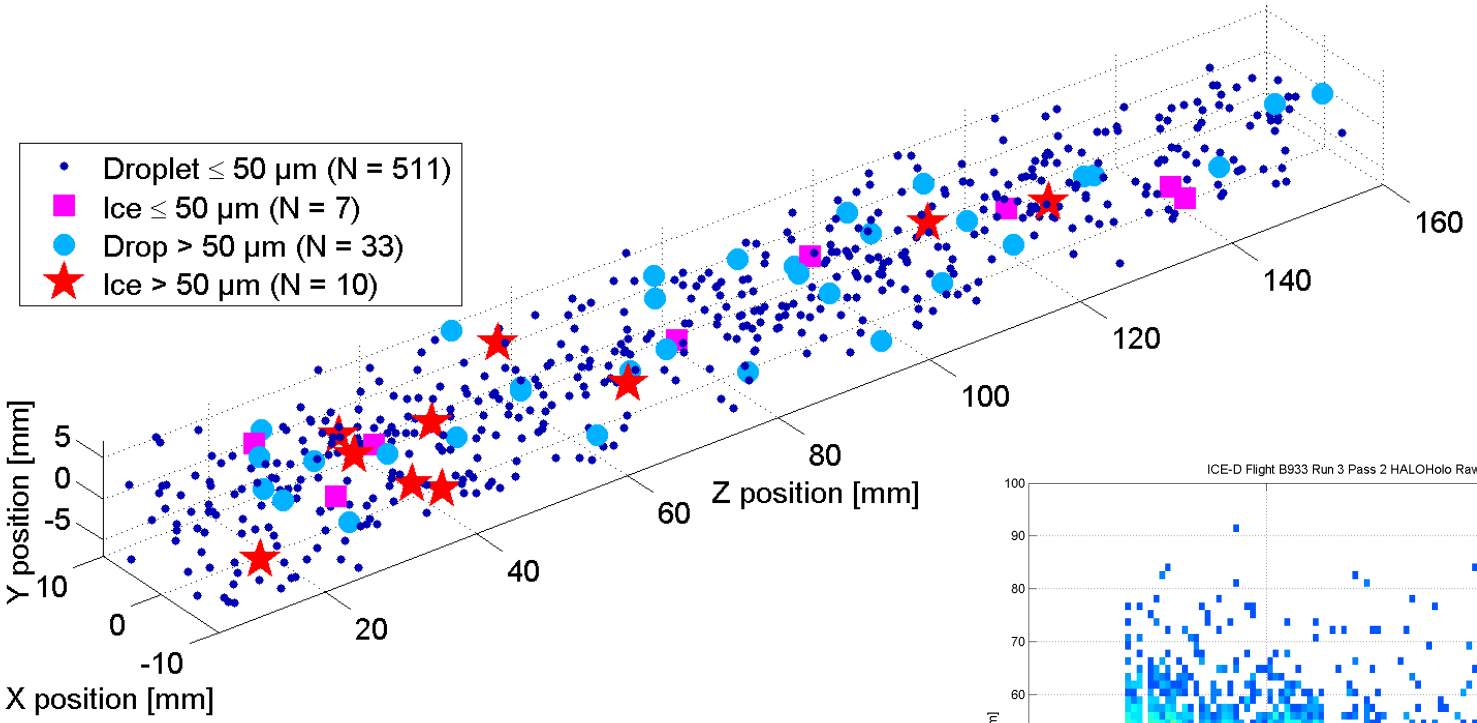


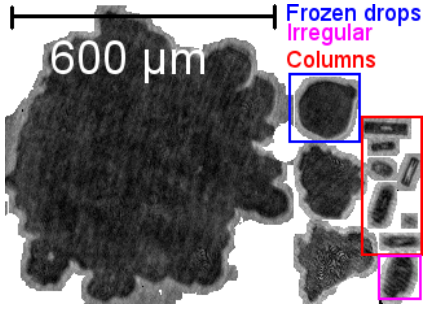


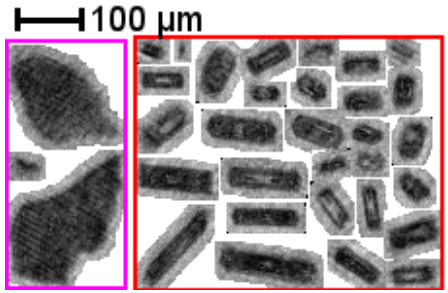
- Mie scattering probes for cloud droplets (CDP, FFSSP)
- Optical array probes for medium-large particles (2DS, HVPS)
- High resolution CCD images of ice crystals (CPI)
- "New" (!untested!) bulk water sensor for accurate IWC (up to 10g/m^3)
- Holographic imager with small particle phase discrimination

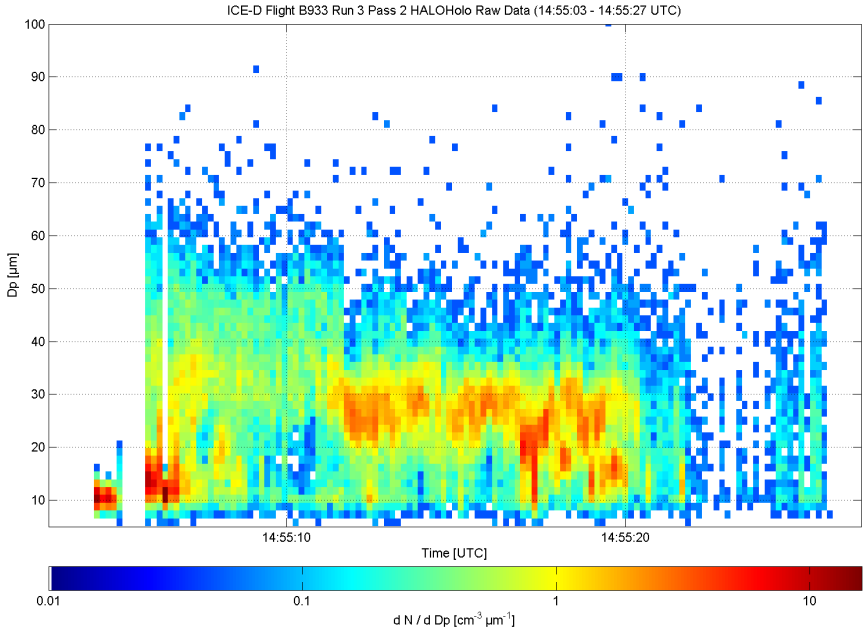
HALO-HOLO holographic imager

Courtesy of Jacob Fugal + Stefan Borrmann at Mainz.



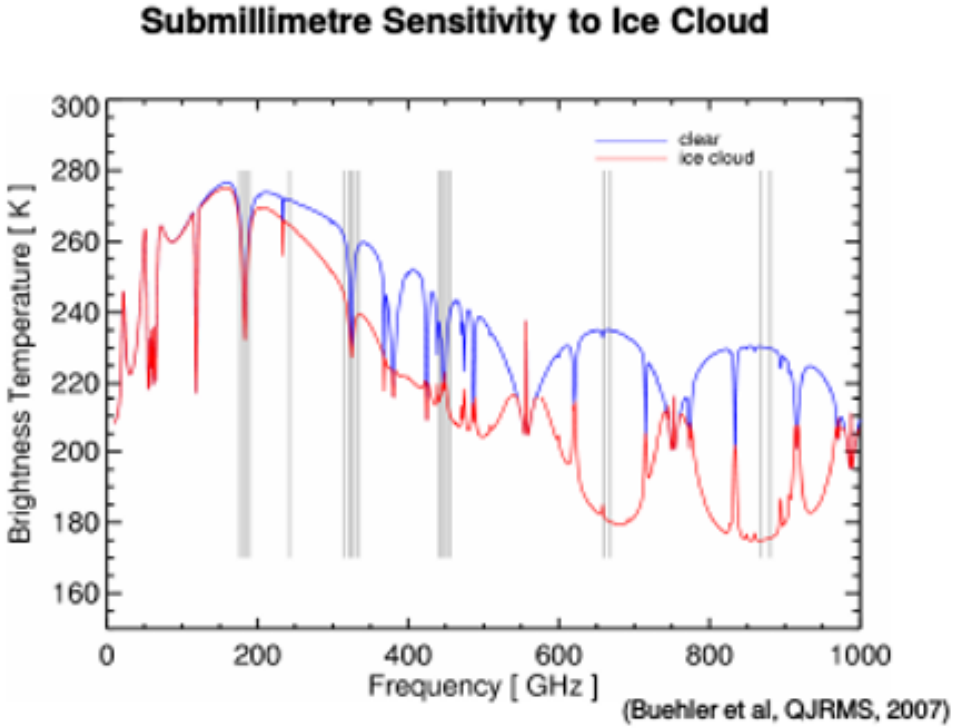






Jacob Fugal

ISMAR
International Sub-Millimetre Airborne Radiometer



- Demonstrator for future ESA “Ice cloud imager” mission
- 118, 243 (V/H), 325, **424**, 448, 664 (V/H) and **874** GHz (V/H)

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Scientific questions

- What is the shape of the particle size distribution (PSD) in ice clouds?
- How does ice and snow particle density vary with particle size?
- Over what temporal and spatial scales does the PSD and particle density vary?
- How do changes in environmental conditions affect the PSD and particle density?
- What level of complexity is required to model the scattering of electromagnetic waves by ice and snow?
- How do observed micro/macro-physical characteristics, and their variability, compare with numerical simulations?
- How do observed micro/macro-physical characteristics, and their variability, compare with remote sensing retirevals?

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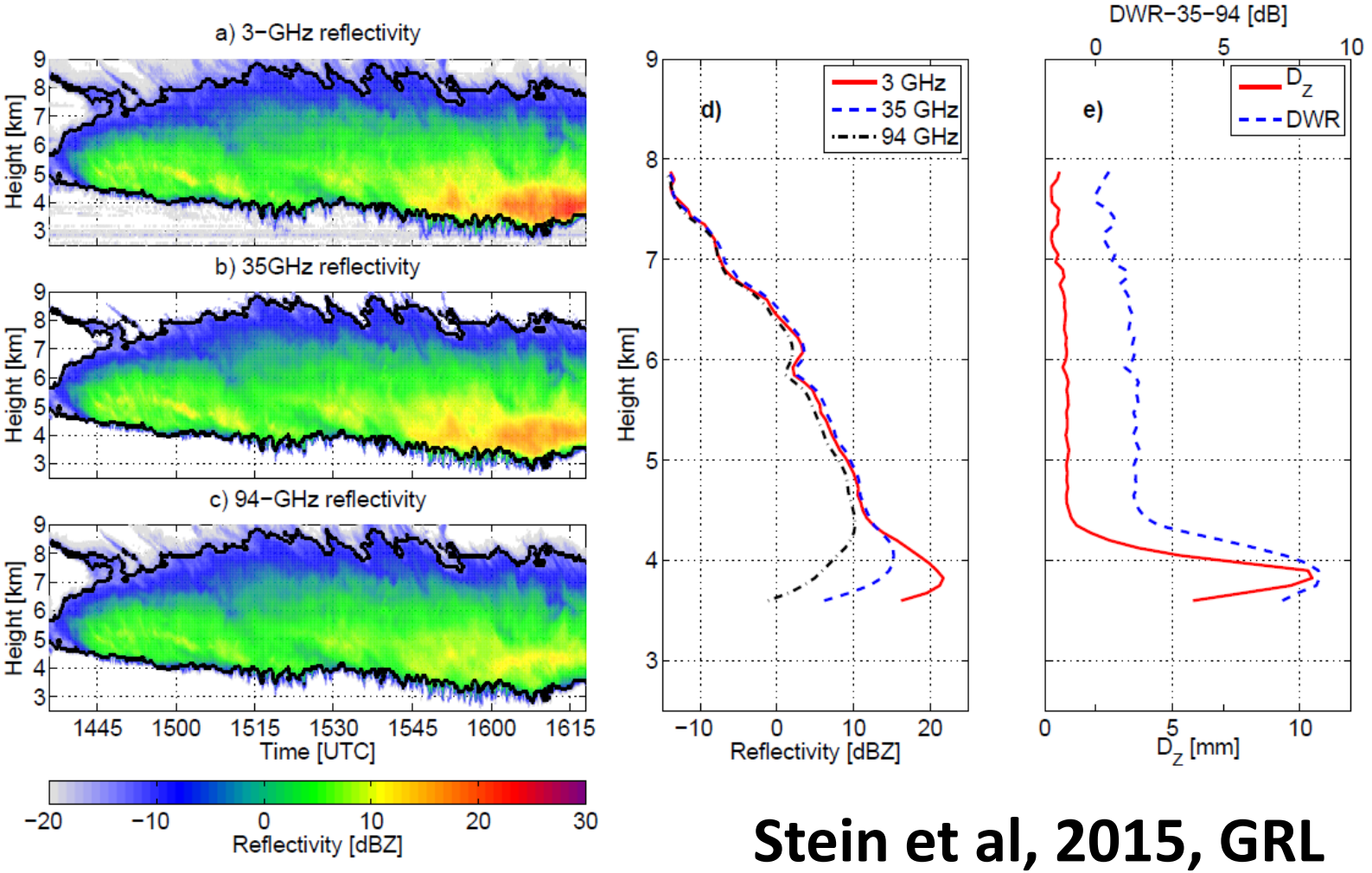
Previous triple frequency studies in the UK



Stein et al, 2015, GRL

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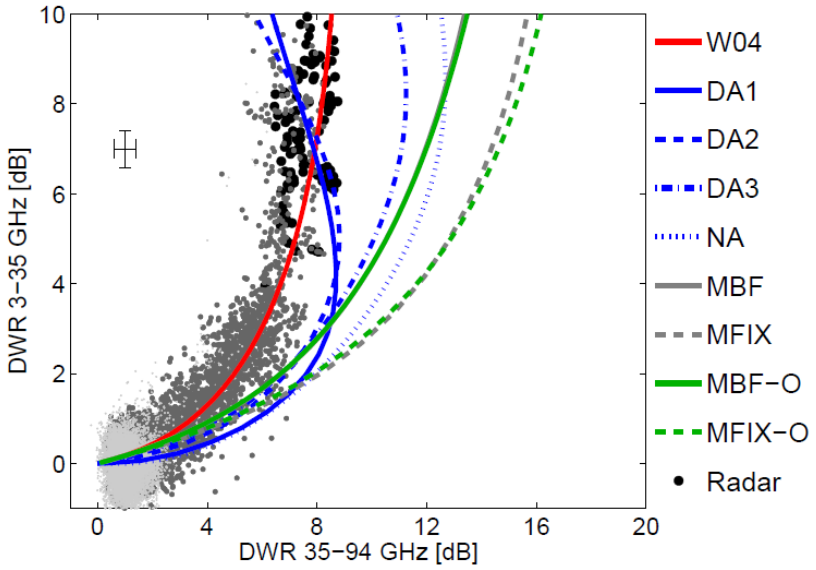

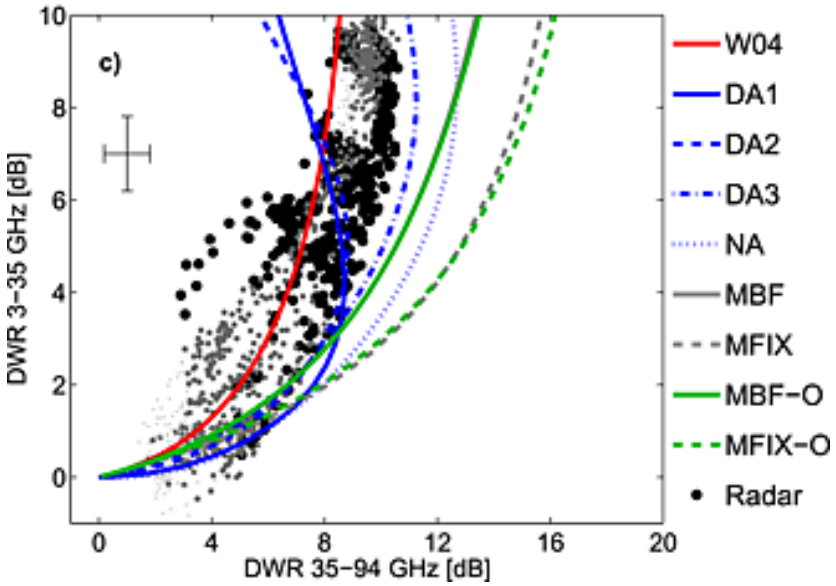

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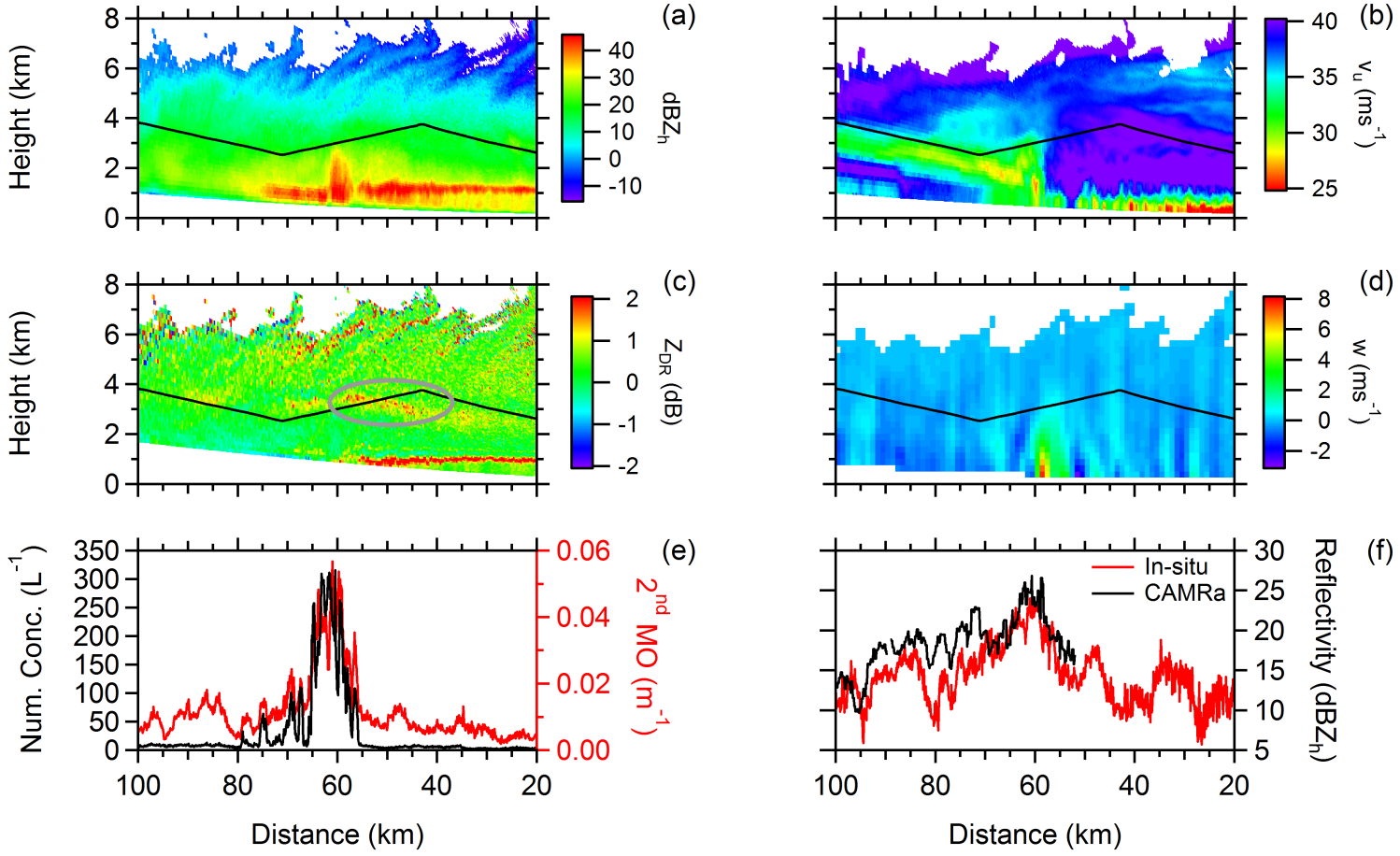
Previous joint Airborne-Radar studies in the UK



Crosier et al, 2014, QJRMS

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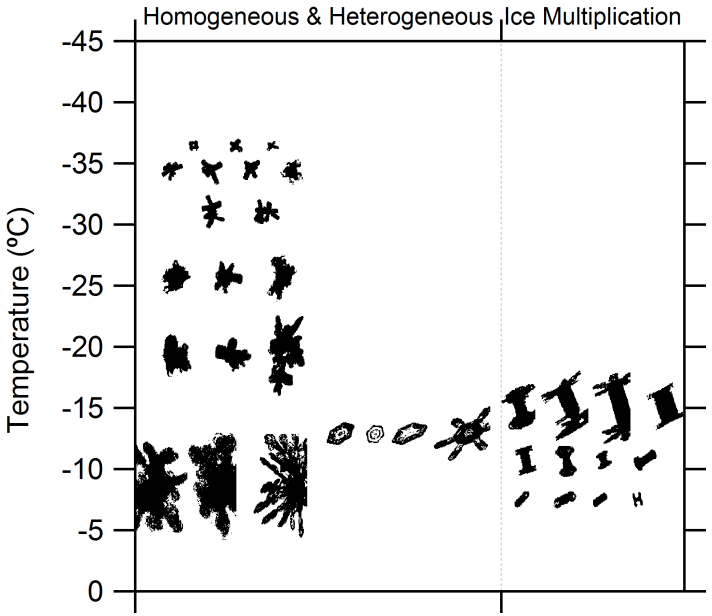

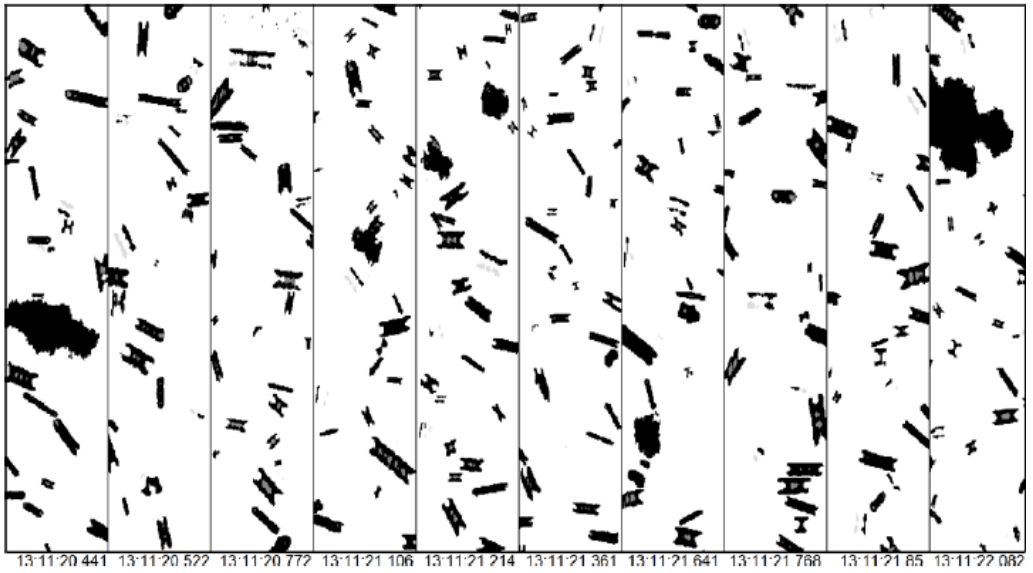

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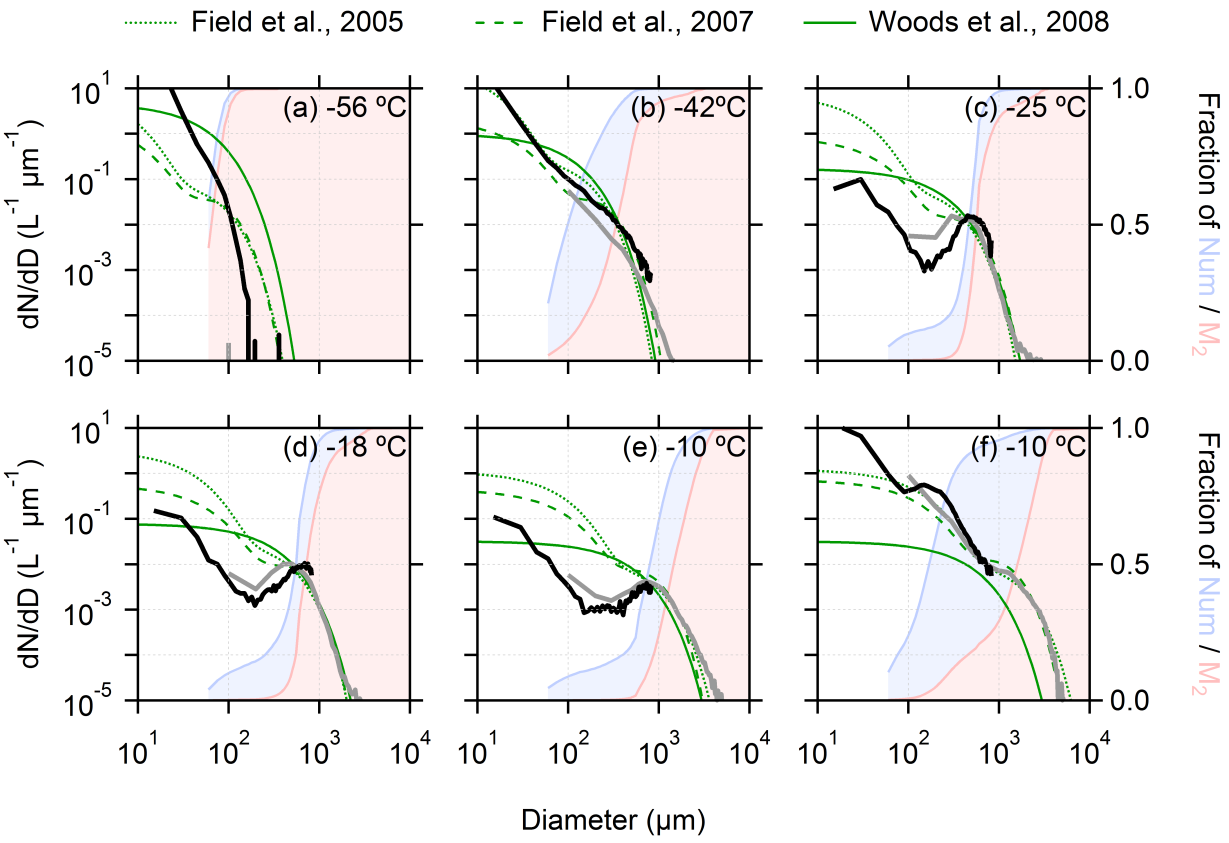

Crosier et al, 2014, QJRMS

AGU PUBLICATIONS

Geophysical Research Letters

RESEARCH LETTER
10.1002/2017GL073441

Ice lollies: An ice particle generated in supercooled conveyor belts

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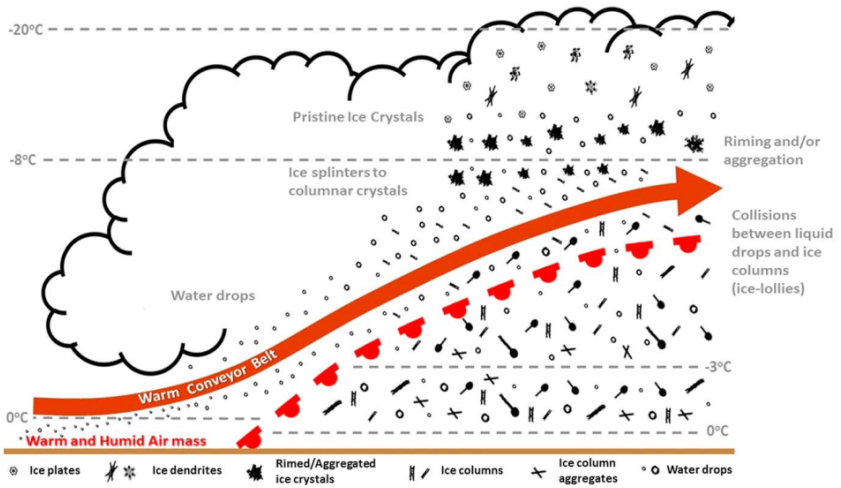
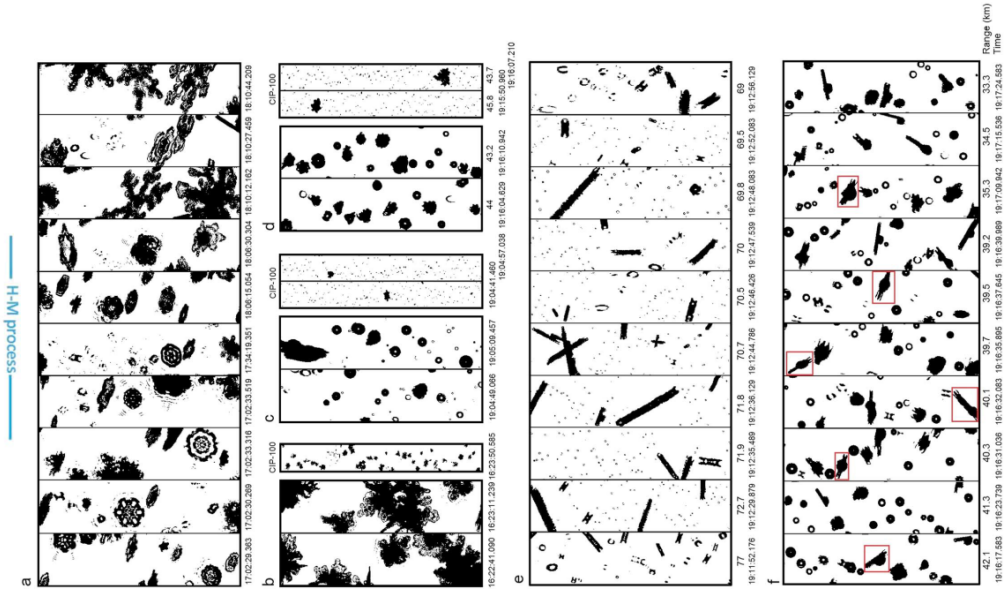
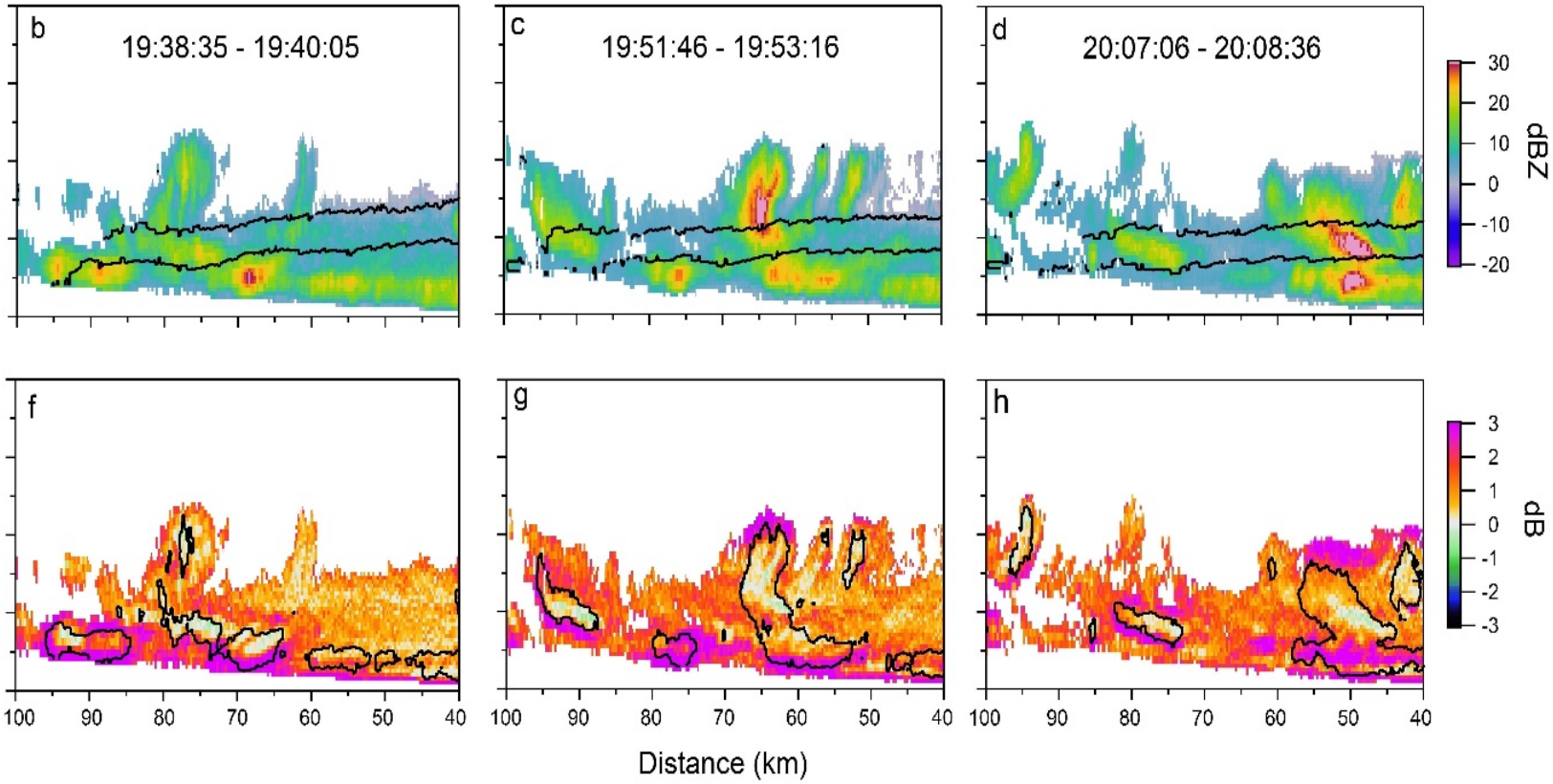
Key Points:

- Ice lollies form when a columnar ice crystal collides with a large water droplet
- Ice-lolly formation rates are highest in

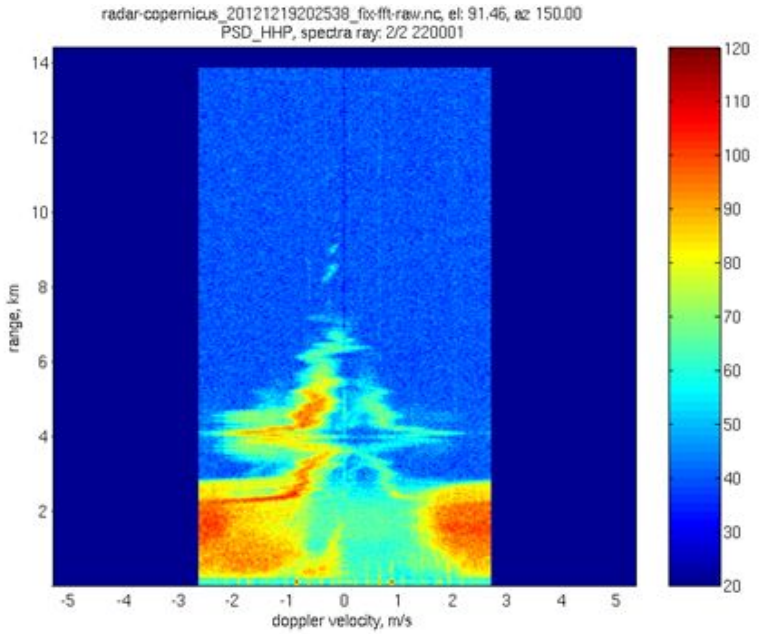


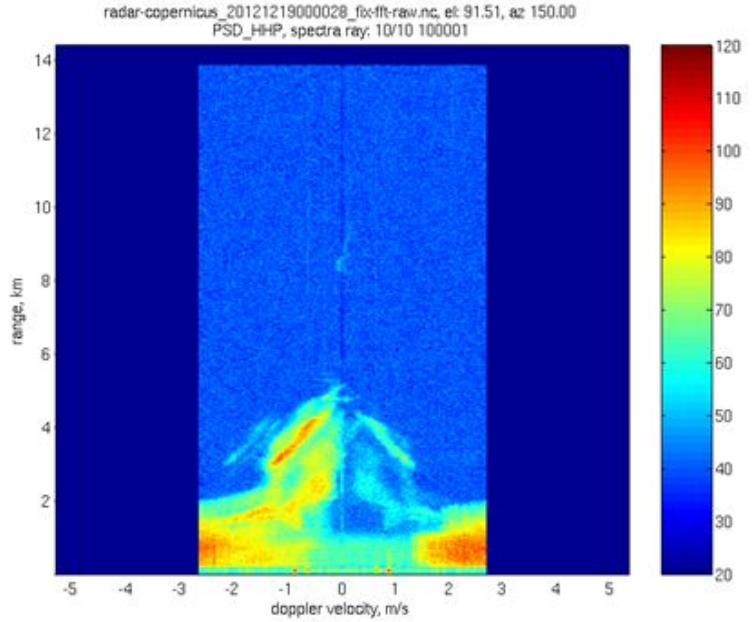


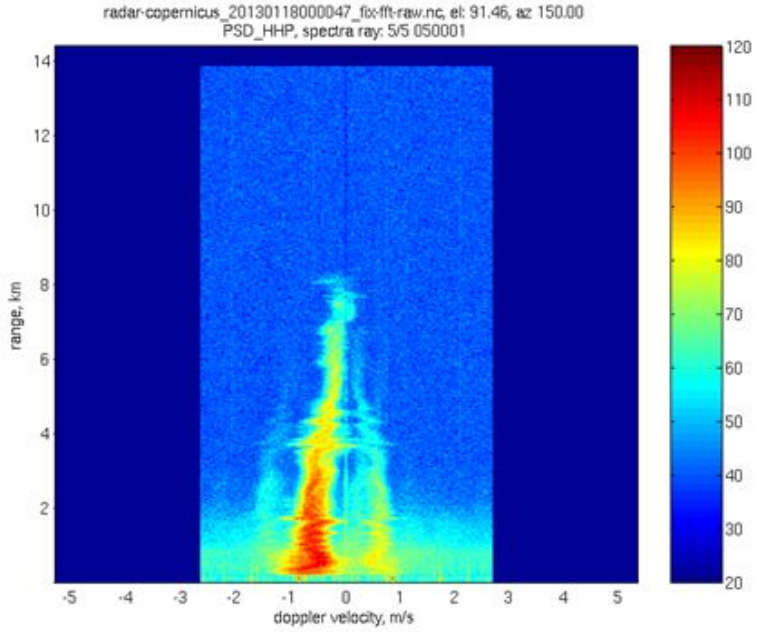
The impact of generating cells on ZDR and particle types



Doppler spectra







Summary

- PICASSO will take place in Jan-April 2018
- Studying the properties of stratiform ice clouds near Chilbolton in the UK (+ some embedded convection)
- Synchronised RHIs at W, Ka and S-band
- Additional data at X and Ka#2
- Aircraft data with enhanced observations, including large particles (HVPS3), small ice (HALO-HOLO) and “improved” bulk water (SEA WCM-2000)
- We will target GPM overpasses
- Open to collaborations